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Socioeconomic status and prostate cancer incidence and mortality rates among the diverse population of California

Iona Cheng · John S. Witte · Laura A. McClure · Sarah J. Shema · Myles G. Cockburn · Esther M. John · Christina A. Clarke

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Abstract
Background The racial/ethnic disparities in prostate cancer rates are well documented, with the highest incidence and mortality rates observed among African-Americans followed by non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders. Whether socioeconomic status (SES) can account for these differences in risk has been investigated in previous studies, but with conflicting results. Furthermore, previous studies have focused primarily on the differences between African-Americans and non-Hispanic Whites, and little is known for Hispanics and Asian/Pacific Islanders.
Objective To further investigate the relationship between SES and prostate cancer among African-Americans, non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders, we conducted a large population-based cross-sectional study of 98,484 incident prostate cancer cases and 8,997 prostate cancer deaths from California.
Methods Data were abstracted from the California Cancer Registry, a population-based surveillance, epidemiology, and end results (SEER) registry. Each prostate cancer case and death was assigned a multidimensional neighborhood-SES index using the 2000 US Census data. SES quintile-specific prostate cancer incidence and mortality rates and rate ratios were estimated using SEER*Stat for each race/ethnicity categorized into 10-year age groups.
Results For prostate cancer incidence, we observed higher levels of SES to be significantly associated with increased risk of disease [SES Q1 vs. Q5: relative risk (RR) = 1.28; 95% confidence interval (CI): 1.25–1.30]. Among younger men (45–64 years), African-Americans had the highest incidence rates followed by non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders for all SES levels. Yet, among older men (75–84 years) Hispanics, following African-Americans, displayed the second highest incidence rates of prostate cancer. For prostate cancer deaths, higher levels of SES were associated with lower mortality rates of prostate cancer deaths (SES Q1 vs. Q5: RR = 0.88; 95% CI: 0.92–0.94). African-Americans had a twofold to fivefold increased risk of prostate cancer deaths in comparison to non-Hispanic Whites across all levels of SES.
Conclusions Our findings suggest that SES alone cannot account for the greater burden of prostate cancer among African-American men. In addition, incidence and mortality rates of prostate cancer display different age and racial/ethnic patterns across gradients of SES.

Keywords Prostate cancer · Socioeconomic status · Disparities · Incidence rates · Mortality rates

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I. Cheng (✉) · J. S. Witte
Department of Epidemiology and Biostatistics and Institute for Human Genetics, University of California, San Francisco, San Francisco, CA 94143-0794, USA
e-mail: chengi@humgen.ucsf.edu

I. Cheng
Epidemiology Program, Cancer Research Center of Hawaii, University of Hawaii, Honolulu, HI 96813, USA

L. A. McClure · S. J. Shema · E. M. John · C. A. Clarke
Northern California Cancer Center, Fremont, CA 94538, USA

M. G. Cockburn
Department of Preventive Medicine, Norris Comprehensive Cancer Center, Keck School of Medicine, University of Southern California, Los Angeles, CA 90089, USA

E. M. John · C. A. Clarke
Department of Health Research & Policy, Stanford Cancer Center, Stanford School of Medicine, Palo Alto, CA 94301, USA

Introduction

Prostate cancer is one of the leading causes of cancer morbidity and mortality among men in the US with 186,320 new cases and 28,660 deaths estimated for 2008 [1]. Striking features of prostate cancer are the pronounced racial/ethnic disparities in incidence and mortality rates. African-Americans experience the highest burden of the disease followed by non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders [2]. Reasons for these racial/ethnic disparities remain poorly understood and are likely due to the interplay of social, environmental, and genetic factors. To better understand the interaction of these factors, the relative contribution of each domain must be thoroughly evaluated in relation to the disparity in rates of prostate cancer.

Socioeconomic status (SES) is linked to several factors that may collectively influence the burden of prostate cancer, including lifestyle and environmental risk factors as well as access, quality, and utilization of screening and health care services [3, 4]. In the years following adoption of prostate specific antigen (PSA) screening for prostate cancer, most studies reported associations between prostate cancer and higher levels of SES [5–9]. However, inconsistent associations have been reported for different racial/ethnic groups [10, 11]. Specifically, a large national US study reported higher SES to be associated with increased incidence of prostate cancer among non-Hispanic Whites, but not among Hispanics or African-Americans [11]; whereas a study of men in the San Francisco Bay Area observed a positive relationship with SES among Asian/Pacific Islanders and Hispanics but not among non-Hispanic Whites and African-Americans [10]. Less controversial are associations of higher SES with lower mortality rates of prostate cancer, which have been documented in multiple studies [12–17].

It remains poorly understood whether SES may account for the substantial racial/ethnic disparities in prostate cancer incidence and mortality among men in the US. Previous studies have largely focused on explaining differences between African-Americans and Whites without consideration of other racial/ethnic groups. These studies generally agree that SES does not entirely explain racial/ethnic differences in prostate cancer incidence [5, 10, 18]. However, findings have been mixed regarding the contribution of SES to survival differences between racial/ethnic groups [13–17, 19–21].

To further clarify the relationship between SES, race/ethnicity, and prostate cancer incidence and mortality, we studied a population-based series of prostate cancer patients with large numbers of African-Americans, non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders for whom small area-level SES information was available.

Materials and methods

Prostate cancer patients

We obtained from the California Cancer Registry (CCR), comprising three of the National Cancer Institute's surveillance, epidemiology, end results (SEER) program registries, data regarding all 102,691 incident cases of invasive prostate cancer (as mandated by state law) and 9,029 prostate cancer deaths reported for two time periods: 1 January 1998 to 31 December 2002 and 1 January 1999 to 31 December 2001 ["International Classification of Diseases for Oncology, Second Edition" (Percy, ICD-0, 1990) site code C619]. These 5-year (incidence) and 3-year (mortality) pericensal periods were chosen because the appropriate census block group-level denominators needed for neighborhood SES rate calculations were available for the 2000 census. Information regarding patient age at cancer diagnosis, race/ethnicity, residential address at diagnosis, and tumor stage and grade was abstracted directly from the medical record. Information regarding prostate cancer deaths, including age, race/ethnicity, and residential address at death, was obtained from death certificates. Race/ethnicity was classified as the following mutually exclusive racial/ethnic groups: African-American, Asian/Pacific Islander, Hispanic (of any race), non-Hispanic White, and other/unknown. We defined nonaggressive disease as tumors that were confined to the prostate and were either well or moderately differentiated. Regional and distant tumors or localized tumors that were poorly differentiated or undifferentiated were classified as aggressive disease. There were 9,712 tumors (9.9%) missing stage or grade information; these tumors were included in all analyses except for stratified analysis by aggressiveness of disease.

We restricted the present study to men aged 45 years and older at diagnosis or death due to prostate cancer, who were of known race/ethnicity. Men aged $\leq$45 years (456 incident cases and 14 deaths) were excluded from analysis due to small numbers as well as those with unknown race/ethnicity (3,751 incident cases and 18 deaths), resulting in a final study population to 98,484 incident prostate cancer cases and 8,997 prostate cancer deaths.

Socioeconomic status and population data

Individual-level SES characteristics (e.g., education, income, and occupation) are not routinely collected by most US cancer registries, including the CCR. However, patient residential address at diagnosis is routinely geocoded by the CCR, and address at death was obtained from California death certificate files. Residential addresses were linked to neighborhood-level SES characteristics from the

US Census Bureau. Census block group (an area containing on average 1,500 residents) was the smallest geographic census unit having information on both SES characteristics and population counts in which we were able to estimate incidence and mortality rates for the decennial census. Patients for whom block group of residence was unknown (incident cases: $n = 5{,}139$, 5.2%; deaths; $n = 253$; 2.8%) were randomly allocated to block groups within the same county. Patients with unknown block group did not differ significantly ($p \leq 0.05$) from patients with known block group on tumor characteristics of stage and grade.

We used a previously developed method [22] to assign a single measure of SES to each California census block group for the time periods in question. Cases diagnosed from 1998–2002 and prostate cancer deaths from 1991–2001 were linked to 2000 census data. Principal component analysis was used to develop a single SES index from seven census-based indicator variables of SES: mean years of education; median household income; percent living 200% below poverty level; percent blue-collar workers; percent older than 16 years in workforce without job; median rent; and median house value [22]. Thus, this index incorporates three critical domains of SES—education, income, and occupation [23]. This index was used to assign a standardized score to each block group, which was then categorized into quintile levels. For each SES quintile, "Supplementary Table 1" shows the distribution of the seven census-based indicator variables of SES and the racial/ethnic distribution among the state of California. Hispanics comprised the largest proportion of subjects for SES quintiles 1 and 2, while non-Hispanic Whites were the largest group for quintiles 3–5. For use as denominators in rate calculation, we obtained population data from age-, sex-, and race-specific population counts for census block groups from the modified age, race, sex, and Hispanic origin ("MARS") files from the 2000 US census. Because population estimates for census block groups were not available for intercensal years, we multiplied the 2000 population counts by five and three, respectively, to estimate the total population at risk for the 5-year period of incidence and 3-year period of mortality.

Statistical analysis

Case counts and population estimates were stratified by 10-year age groups, race/ethnicity, and neighborhood SES quintile. Prostate cancer incidence and mortality rates were calculated per 100,000 individuals. SES quintile-specific incidence and mortality rate ratios (RR) and 95% confidence intervals (CI) were estimated and when appropriate age adjusted to the 2000 US standard population using SEER*Stat, version 6.3.4.

Results

Socioeconomic status and prostate cancer incidence

For 98,484 incident cases of prostate cancer, the distribution of race/ethnicity, stage, grade, and neighborhood SES quintile varied by 10-year age group (Table 1). Non-Hispanic Whites represented over 68% of all cases across all age groups. African-Americans cases were the second largest racial/ethnic group (15%) among the youngest age group (45–54 years) but the smallest group (6%) among the oldest age group (85+ years). Hispanics and Asian/Pacific Islanders represented 10–14% and 4–7% of the cases, respectively, across the 10-year age groups. The majority of cases was of a nonaggressive type, localized disease, and moderately differentiated.

Higher incidence rates of prostate cancer were associated with increasing levels of SES across all racial/ethnic groups (Table 2). Among all racial/ethnic groups combined, those at the highest quintile of SES had a 28% higher incidence rate of prostate cancer than those in the lowest quintile (95% CI: 1.25–1.30). The largest difference in SES-specific rates was observed among Hispanics, with an incidence rate of prostate cancer that was 80% higher among men in the highest quintile of SES in comparison to those in the lowest SES quintile (95% CI: 1.68–1.92). In a stratified analysis by severity of disease, a similar pattern was observed for both nonaggressive and aggressive disease such that significantly higher rates of prostate cancer were observed with increasing gradients of SES (Table 2). In particular, for men with aggressive disease those at the highest quintile of SES had a 1.2-fold significant increased risk of prostate cancer than those at the lowest SES quintile. This same pattern was seen for all four racial/ethnic groups.

In contrast to the expected exponential increase in prostate cancer incidence with age [24], for all SES levels a peak in incidence rate was seen for African-Americans and non-Hispanic Whites at 65–74 years of age, while for Hispanics and Asians/Pacific Islanders incidence rates peaked at 75–84 years (Table 3). Furthermore, different racial/ethnic-specific patterns in incidence rates were seen for younger and older age groups. Specifically, among younger men aged 45–64 years, African-Americans had the highest incidence rates followed by non-Hispanic Whites, Hispanics, and Asians for each level of SES. Most notably, African-Americans (45–64 years) had a significant twofold higher incidence rate of prostate cancer in comparison to non-Hispanic Whites, irrespective of SES. Among older men aged 75–84 years, Hispanics, following African-Americans, had the second highest incidence rates of prostate cancer across all SES quintiles, while non-Hispanics Whites and Asians had the lowest incidence

Table 1 Characteristics of incident prostate cancer cases by 10-year age groups, California, 1998–2002 ($n = 98,484$)

Years	45–54	55–64	65–74	75–84	85+
Number	7,374	25,712	38,206	22,390	4,802
Race/ethnicity, *n* (%)					
Non-Hispanic White	4,986 (67.6)	18,035 (70.1)	26,958 (70.6)	16,694 (74.6)	3,719 (77.4)
African-American	1,101 (14.9)	3,065 (11.9)	3,203 (8.4)	1,362 (6.1)	290 (6.0)
Hispanic	979 (13.3)	3,340 (13.0)	5,393 (14.1)	2,675 (11.9)	497 (10.3)
Asian/Pacific Islander	308 (4.2)	1,275 (5.0)	2,652 (6.9)	1,659 (7.4)	296 (6.2)
Severity, *n* (%)[a]					
Non-aggressive	5,272 (74.8)	18,292 (74.6)	26,399 (73.8)	13,300 (69.6)	1,511 (53.8)
Aggressive	1,775 (25.2)	6,241 (25.4)	9,391 (26.2)	5,805 (30.4)	1,295 (46.1)
Stage, *n* (%)[a]					
Localized	6,089 (84.3)	21,530 (85.7)	32,484 (88.0)	17,638 (87.0)	2,520 (74.9)
Regional/distant	1,136 (15.7)	3,593 (14.3)	4,442 (12.0)	2,625 (13.0)	846 (25.1)
Grade, *n* (%)[a]					
Well differentiated; I	244 (3.4)	1,022 (4.1)	1,887 (5.1)	1,228 (6.1)	190 (6.2)
Moderately differentiated; II	5,758 (80.5)	19,673 (78.8)	27,205 (74.2)	13,548 (67.2)	1,595 (52.0)
Poorly/undifferentiated; III/IV	1,155 (16.1)	4,277 (17.1)	7,565 (20.6)	5,375 (26.7)	1,281 (41.2)
Socioeconomic status quintile, *n* (%)					
Q1	771 (10.5)	2,916 (11.3)	4,855 (12.7)	2,926 (13.1)	690 (14.4)
Q2	1,121 (15.2)	4,040 (15.7)	6,482 (17.0)	4,025 (18.0)	944 (19.7)
Q3	1,527 (20.7)	5,085 (19.8)	7,962 (20.8)	4,674 (20.9)	1,008 (21.0)
Q4	1,780 (24.1)	5,650 (22.0)	8,496 (22.2)	4,991 (22.3)	1,074 (22.3)
Q5	2,175 (29.5)	8,021 (31.2)	10,411 (27.2)	5,774 (25.8)	1,086 (22.6)

[a] Numbers do not add up to 98,484 due to missing data

rates. This pattern was similar among men aged ≥85 years with the exception of those at the lowest SES level. For aggressive prostate cancer, incidence rates were highest for African-Americans in all age groups and were twofold to threefold higher than the rates of non-Hispanic Whites among men aged 45–64 years (see "Supplementary Table 2"). Among men aged 65–84 years, higher incidence rates were also noted in Hispanic men, with rates between those of African-Americans and non-Hispanics and Whites, particularly among those at higher SES levels (Q3, Q4, and Q5) (see "Supplementary Table 2").

Socioeconomic status and prostate cancer mortality

Table 4 shows distributions of the 8,997 prostate cancer deaths by race/ethnicity and SES. Non-Hispanic Whites comprised the majority (55 to 79%) of deaths in all age groups. SES and prostate cancer mortality rates were inversely associated with decreasing mortality rates seen with increasing levels of SES (Table 5). Men at the highest quintile of SES had a 12% significant reduction in risk of prostate cancer death compared to men at the lowest SES quintile (RR = 0.88; 95% CI: 0.82–0.94). Although within each racial/ethnic group there were no significant differences in mortality rates across levels of SES, non-Hispanic Whites demonstrated a trend of lower morality rates associated with higher SES levels (Table 5).

Table 6 displays the racial/ethnic-specific patterns of prostate cancer mortality rates across SES levels by 10-year age groups. Across all age groups, African-Americans had the highest mortality rates of prostate cancer for all quintiles of SES, with mortality rates that were twofold to fivefold higher than those of non-Hispanics Whites. Asian/Pacific Islanders had the lowest rates of prostate cancer mortality for all SES quintiles that were generally less than half that of the rates of non-Hispanic Whites. In most age and SES groups, Hispanics had slightly lower mortality rates than non-Hispanic Whites.

Discussion

In this large multiethnic population, population-based series of prostate cancer patients, increasing levels of SES were associated with higher incidence and lower mortality rates of prostate cancer. Furthermore, across all levels of SES, African-Americans had a substantially larger burden of prostate cancer deaths than other racial/ethnic groups, suggesting that SES alone cannot entirely account for the racial/ethnic differences in prostate cancer mortality.

Table 2 Prostate cancer (PCa) incidence rates (per 100,000) among men 45 years and older by SES and race/ethnicity, California 1998–2002

	SES	Total PCa			Localized PCa			Aggressive PCa		
		n	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)
All	Q1	12,158	411.7	1.00	7,383	84.4	1.00	3,177	37.3	1.00
	Q2	16,612	401.1	0.97 (0.95–1.00)	10,501	86.7	1.03 (1.00–1.06)	4,371	36.7	0.98 (0.94–1.04)
	Q3	20,256	434.0	1.05 (1.03–1.08)	13,359	98.1	1.16 (1.13–1.20)	4,991	37.3	1.00 (0.96–1.05)
	Q4	21,991	455.6	1.11 (1.08–1.13)	14,783	104.9	1.24 (1.21–1.28)	5,451	39.4	1.06 (1.01–1.11)
	Q5	27,467	525.5	1.28 (1.25–1.30)	19,044	124.3	1.47 (1.43–1.51)	6,633	44.7	1.20 (1.15–1.25)
Non-Hispanic White	Q1	4,788	441.6	1.00	2,960	94.8	1.00	1,199	38.6	1.00
	Q2	10,251	399.8	0.91 (0.87–0.94)	6,546	88.6	0.93 (0.89–0.98)	2,640	36.0	0.93 (0.87–1.00)
	Q3	14,744	435.5	0.99 (0.95–1.02)	9,833	100.6	1.06 (1.02–1.11)	3,491	36.0	0.93 (0.87–1.00)
	Q4	17,115	460.4	1.04 (1.01–1.08)	11,630	108.0	1.14 (1.10–1.19)	4,112	38.6	1.00 (0.94–1.07)
	Q5	23,494	545.4	1.24 (1.20–1.27)	16,397	130.5	1.38 (1.32–1.43)	5,538	45.2	1.17 (1.10–1.25)
African-American	Q1	2,710	711.3	1.00	1,599	142.0	1.00	697	63.5	1.00
	Q2	2,165	702.7	0.99 (0.93–1.05)	1,350	146.3	1.03 (0.96–1.11)	583	65.6	1.03 (0.92–1.16)
	Q3	1,776	738.7	1.04 (0.97–1.11)	1,180	162.9	1.15 (1.06–1.24)	439	62.8	0.99 (0.87–1.13)
	Q4	1,500	798.1	1.12 (1.05–1.20)	1,006	176.7	1.24 (1.14–1.36)	386	70.5	1.11 (0.97–1.28)
	Q5	867	933.7	1.31 (1.22–1.43)	614	219.5	1.55 (1.40–1.71)	220	85.1	1.34 (1.13–1.60)
Hispanic	Q1	3,946	348.7	1.00	2,407	70.4	1.00	30	32.0	1.00
	Q2	3,147	393.1	1.13 (1.07–1.19)	1,950	80.6	1.15 (1.07–1.22)	34.1	36.6	1.14 (1.04–1.26)
	Q3	2,511	440.7	1.26 (1.20–1.33)	1,595	93.7	1.33 (1.24–1.43)	37.4	40.5	1.27 (1.14–1.41)
	Q4	1,837	471.0	1.35 (1.27–1.43)	1,179	99.8	1.42 (1.32–1.53)	41.1	45.2	1.41 (1.26–1.59)
	Q5	1,443	625.9	1.80 (1.68–1.92)	967	139.1	1.98 (1.82–2.14)	53.2	59.3	1.85 (1.63–2.11)
Asian/Pacific Islander	Q1	714	234.3	1.00	417	47.1	1.00	208	24.0	1.00
	Q2	1,049	242.6	1.04 (0.94–1.14)	655	51.9	1.10 (0.97–1.25)	282	22.5	0.94 (0.78–1.14)
	Q3	1,225	278.1	1.19 (1.08–1.31)	751	57.8	1.23 (1.09–1.39)	385	30.4	1.27 (1.07–1.52)
	Q4	1,539	306.5	1.31 (1.19–1.43)	968	64.1	1.36 (1.21–1.53)	443	31.4	1.31 (1.11–1.56)
	Q5	1,663	297.4	1.27 (1.16–1.39)	1,066	62.9	1.33 (1.19–1.50)	487	31.4	1.31 (1.11–1.56)

Age-adjusted to the 2000 US standard population

The elevated incidence rate of prostate cancer associated with higher levels of SES is likely attributable at least in some part to variation in access and utilization of health services; in particular, prostate cancer screening through PSA testing. PSA testing greatly increases the detection of prostate tumors, which leads at the population-level to elevated incidence rates of prostate cancer. Studies have reported that men at higher levels of SES are more likely to undergo PSA testing [25, 26], ultimately influencing the amount of disease in the population. The peak in incidence rates of prostate cancer among non-Hispanics Whites and African-Americans at 65–74 years of ages are in agreement with previous SEER reports [2] and may reflect heavier screening practices at earlier ages, while the later peak among Hispanics and Asian/Pacific Islanders at 75–84 years may reflect later adoption and lower utilization of PSA screening. Prior research has shown that Asians and Hispanics are less likely to receive physician discussions of PSA testing than higher risk Whites and African-Americans [27].

A consistent racial/ethnic-specific pattern of incidence rates across SES levels was observed only among younger adult men (<65 years). To our knowledge, our findings of an increased incidence of prostate cancer among older Hispanics (75–85 years) at the higher levels of SES relative to non-Hispanic Whites have not been reported previously. In a national study of cancer among US Hispanics, Howe et al. [11] reported that Hispanics are less likely to have health care coverage than non-Hispanics Whites, especially among those younger than 65 years. With more health care coverage for older Hispanics and better resources for those at higher levels of SES, such men may have improved access and utilization of screening services that otherwise may have not been available—this may account for the higher incidence rates among this particular group of Hispanics. Our findings are in line with two similar yet smaller studies in Los Angeles [5] and the San Francisco Bay Area [10] in which across all levels of SES a similar racial/ethnic-specific pattern in age-adjusted incidence rates were seen with the exception of greater

Table 3 Prostate cancer incidence rates (per 100,000) by SES and race/ethnicity for 10-year age groups, California 1998–2002

SES	Race/ethnicity	45–54 Years			55–64 Years			65–74 Years			75–84 Years			85+ Years		
		n	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)
Q1	Non-Hispanic White	267	67.7	1.00	1,062	397.9	1.00	1,847	879.3	1.00	1,253	861.4	1.00	359	859.2	1.00
	African-American	236	143.4	2.12 (1.77–2.53)	830	757.2	1.90 (1.74–2.09)	1,012	1351.3	1.54 (1.42–1.66)	513	1245.8	1.45 (1.30–1.60)	119	1118.9	1.30 (1.05–1.61)
	Hispanic	251	30.7	0.45 (0.38–0.54)	921	224.5	0.56 (0.52–0.62)	1,696	720.6	0.82 (0.77–0.88)	908	872.1	1.01 (0.93–1.10)	170	714.6	0.83 (0.69–1.00)
	Asian/Pacific Islander	17	14.1	0.21 (0.12–0.34)	103	132.8	0.33 (0.27–0.41)	300	489.2	0.56 (0.49–0.63)	252	659.6	0.77 (0.67–0.88)	42	404.2	0.47 (0.33–0.65)
Q2	Non-Hispanic White	596	61.3	1.00	2,346	370.9	1.00	3,942	793.7	1.00	2,710	788.5	1.00	657	704.3	1.00
	African-American	254	164.4	2.68 (2.31–3.11)	676	726.5	1.96 (1.80–2.14)	791	1315.2	1.66 (1.53–1.79)	358	1186.2	1.50 (1.34–1.68)	86	1241.9	1.76 (1.39–2.21)
	Hispanic	225	41.7	0.68 (0.58–0.79)	833	306.1	0.83 (0.76–0.89)	1,320	792.6	1.00 (0.93–1.06)	636	879.3	1.12 (1.02–1.22)	133	830.5	1.18 (0.97–1.42)
	Asian/Pacific Islander	46	22.6	0.37 (0.27–0.50)	185	146.9	0.40 (0.34–0.46)	429	480.9	0.61 (0.54–0.67)	321	631.3	0.80 (0.71–0.90)	68	554.2	0.79 (0.60–1.01)
Q3	Non-Hispanic White	1,024	75.1	1.00	3,529	417.4	1.00	5,758	887.0	1.00	3,618	800.5	1.00	815	693.6	1.00
	African-American	239	185.9	2.47 (2.14–2.85)	657	838.4	2.01 (1.84–2.18)	606	1376.2	1.55 (1.42–1.70)	231	1188.9	1.49 (1.29–1.70)	43	967.4	1.39 (1.00–1.90)
	Hispanic	201	54.1	0.72 (0.62–0.84)	652	339.5	0.81 (0.75–0.88)	1,041	902.0	1.02 (0.95–1.09)	523	997.4	1.25 (1.14–1.37)	94	798.0	1.15 (0.92–1.43)
	Asian/Pacific Islander	63	27.6	0.37 (0.28–0.47)	247	183.6	0.44 (0.39–0.50)	557	609.5	0.69 (0.63–0.75)	302	645.3	0.81 (0.72–0.91)	56	515.4	0.74 (0.56–0.97)
Q4	Non-Hispanic White	1,288	78.1	1.00	4,250	441.4	1.00	6,568	949.7	1.00	4,095	845.9	1.00	914	692.5	1.00
	African-American	225	195.2	2.50 (2.16–2.88)	580	910.7	2.06 (1.89–2.25)	502	1554.8	1.64 (1.49–1.80)	158	1160.0	1.37 (1.16–1.61)	35	1138.2	1.64 (1.14–2.30)
	Hispanic	172	68.7	0.88 (0.75–1.03)	523	399.4	0.90 (0.82–0.99)	747	953.6	1.00 (0.93–1.08)	338	1021.8	1.21 (1.08–1.35)	57	724.3	1.05 (0.79–1.37)
	Asian/Pacific Islander	95	33.2	0.43 (0.34–0.52)	297	185.0	0.42 (0.37–0.47)	679	654.8	0.69 (0.64–0.75)	400	760.5	0.90 (0.81–1.00)	68	569.8	0.82 (0.63–1.05)
Q5	Non-Hispanic White	1,811	92.6	1.00	6,848	564.0	1.00	8,843	1113.6	1.00	5,018	957.4	1.00	974	766.7	1.00
	African-American	147	240.4	2.60 (2.18–3.07)	319	952.7	1.69 (1.50–1.89)	292	1892.7	1.70 (1.50–1.92)	102	1718.1	1.79 (1.46–2.19)	7	503.6	0.66 (0.26–1.36)
	Hispanic	130	85.4	0.92 (0.77–1.10)	411	503.0	0.89 (0.81–0.99)	589	1308.3	1.17 (1.08–1.28)	270	1374.3	1.44 (1.26–1.63)	43	946.1	1.23 (0.88–1.67)
	Asian/Pacific Islander	87	24.1	0.26 (0.21–0.32)	443	229.7	0.41 (0.37–0.45)	687	616.9	0.55 (0.51–0.60)	384	696.8	0.73 (0.65–0.81)	62	539.1	0.70 (0.54–0.91)

Age-adjusted to the 2000 US standard population

Table 4 Characteristics of prostate cancer deaths by 10-year age groups, California, 1999–2001 ($n = 8{,}997$)

Years	45–54	55–64	65–74	75–84	85+
Number	125	596	1910	3787	2579
Race/ethnicity, *n* (%)					
Non-Hispanic White	69 (55.2)	397 (66.6)	1,291 (67.6)	2,887 (76.2)	2044 (79.3)
African-American	29 (23.2)	112 (18.8)	289 (15.1)	367 (9.7)	185 (7.2)
Hispanic	25 (20.0)	74 (12.4)	276 (14.5)	367 (9.7)	211 (8.2)
Asian/Pacific Islander	2 (1.6)	13 (2.2)	54 (2.8)	166 (4.4)	139 (5.4)
Socioeconomic status quintile, *n* (%)					
Q1	24 (19.2)	94 (15.8)	315 (16.5)	527 (13.9)	345 (13.4)
Q2	27 (21.6)	147 (24.7)	408 (21.4)	735 (19.4)	527 (20.4)
Q3	26 (20.8)	131 (22.0)	414 (21.7)	870 (23.0)	560 (21.7)
Q4	25 (20.0)	126 (21.1)	382 (20.0)	870 (23.0)	572 (22.2)
Q5	23 (18.4)	98 (16.4)	391 (20.5)	785 (20.7)	575 (22.3)

Table 5 Prostate cancer mortality rates (per 100,000) among men 45 years and older by SES and race/ethnicity, California 1999–2001

SES	All			Non-Hispanic White			African-American			Hispanic			Asian/Pacific Islander		
	n	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)
Q1	1,305	33.5	1.00	559	33.1	1.00	355	67.6	1.00	338	27.3	1.00	53	13.9	1.00
Q2	1,844	32.5	0.97 (0.90–1.04)	1,254	32.6	0.99 (0.89–1.09)	254	64.8	0.96 (0.81–1.13)	243	27.1	0.99 (0.83–1.18)	93	19.3	1.38 (0.97–1.99)
Q3	2,001	31.0	0.93 (0.86–0.99)[a]	1,576	31.4	0.95 (0.86–1.05)	176	64.7	0.96 (0.79–1.15)	177	27.9	1.02 (0.84–1.24)	72	15.1	1.09 (0.74–1.59)
Q4	1,975	29.6	0.88 (0.82–0.95)[a]	1,635	29.9	0.91 (0.82–1.00)	134	72.5	1.07 (0.87–1.32)	123	27.9	1.02 (0.82–1.27)	83	15.9	1.14 (0.79–1.65)
Q5	1,872	29.5	0.88 (0.82–0.94)[a]	1,664	30.7	0.93 (0.84–1.02)	63	73.5	1.09 (0.81–1.44)	72	27.8	1.02 (0.77–1.33)	73	14.0	1.01 (0.69–1.47)

Age-adjusted to the 2000 US standard population

[a] The overall lower mortality rate in comparison with racial/ethnic specific rates is attributed to non-Hispanic Whites and Asian/Pacific Islanders having larger population denominators at the higher SES levels in comparison with lower SES levels with Blacks and Hispanics having larger population denominators at lower SES levels in comparison

incidence of prostate cancer among Hispanics than that of Whites for those at the higher levels of SES. Age-stratified effects as shown in our study were not examined in these previous reports [5, 10].

Because screening practices greatly influence the incidence rates of prostate cancer, we also examined mortality as it may serve as a better index of risk across groups and may reflect the most clinically relevant forms of disease. The lower mortality rates of prostate cancer seen with higher levels of SES are likely attributed to factors linked to a better health status by affording optimal use of medical services such as early detection and treatment regimens, acquiring pertinent health information and education, and avoiding high risk health behaviors [15]. This overall inverse association between mortality and SES was largely driven by non-Hispanics Whites with the remaining racial/ethnic groups demonstrating no association. This could be explained due to insufficient power among the remaining racial/ethnic groups given their smaller numbers of deaths and fewer overall Census numbers at higher levels of SES. In addition, this could be due to inadequacy of our SES index in capturing SES parameters that are most relevant for certain non-White racial/ethnic groups (discussed below). Lastly, these findings may suggest that SES does not play a role in prostate cancer mortality among African-Americans, Hispanics, and Asian/Pacific Islanders.

For every level of SES, African-Americans had the highest burden of prostate cancer deaths in comparison to other three racial/ethnic groups. These findings are in agreement with three previous studies that reported that the measures of SES cannot account for the differences in mortality/survival between African-Americans and Whites

Table 6 Prostate cancer mortality rates (per 100,000) by SES and race/ethnicity for 10-year age groups, California 1999–2001

SES	Race/ethnicity	45–54 years			55–64 years			65–74 years			75–84 years			85+ years		
		n	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)	*n*	Rate	RR (95% CI)
Q1	Non-Hispanic White	9	1.9	1.00	36	10.9	1.00	105	37.3	1.00	233	103.7	1.00	176	205.4	1.00
	African-American	6	2.8	1.46 (0.43–4.59)	31	21.1	1.93 (1.15–3.21)	106	99.9	2.68 (2.02–3.54)	138	213.8	2.06 (1.66–2.56)	74	332.9	1.62 (1.22–2.14)
	Hispanic	9	0.9	0.47 (0.16–1.35)	26	5.0	0.46 (0.27–0.78)	94	29.6	0.79 (0.59–1.06)	132	90.3	0.87 (0.70–1.08)	77	189.9	0.92 (0.70–1.22)
	Asian/Pacific Islander	–	–	–	<5	1.0	0.09 (0.002–0.54)	10	11.8	0.31 (0.15–0.60)	24	46.8	0.45 (0.28–0.69)	18	122.2	0.60 (0.34–0.97)
Q2	Non-Hispanic White	12	1.0	1.00	89	11.3	1.00	253	38.0	1.00	510	98.9	1.00	390	212.4	1.00
	African-American	9	4.4	4.28 (1.59–11.12)	34	27.0	2.39 (1.56–3.59)	71	86.5	2.28 (1.72–2.98)	92	198.4	2.01 (1.59–2.51)	48	323.5	1.52 (1.10–2.06)
	Hispanic	5	0.7	0.71 (0.20–2.21)	21	6.0	0.53 (0.31–0.86)	72	31.9	0.84 (0.64–1.10)	97	92.7	0.94 (0.75–1.17)	48	164.7	0.78 (0.56–1.05)
	Asian/Pacific Islander	<5	0.4	0.36 (0.01–2.45)	<5	1.8	0.16 (0.03–0.49)	12	9.6	0.25 (0.13–0.45)	36	52.0	0.53 (0.36–0.74)	41	228.1	1.07 (0.76–1.48)
Q3	Non-Hispanic White	15	0.9	1.00	89	8.4	1.00	286	33.2	1.00	715	106.2	1.00	471	200.6	1.00
	African-American	8	4.9	5.35 (1.96–13.47)	23	22.9	2.72 (1.64–4.34)	63	112.5	3.39 (2.53–4.48)	56	184.1	1.73 (1.30–2.28)	26	271.7	1.35 (0.88–2.01)
	Hispanic	<5	0.6	0.70 (0.13–2.51)	14	5.6	0.66 (0.35–1.17)	51	32.1	0.97 (0.70–1.31)	68	91.5	0.86 (0.66–1.11)	41	188.8	0.94 (0.67–1.30)
	Asian/Pacific Islander	–	–	–	5	2.8	0.33 (0.11–0.81)	14	10.8	0.33 (0.18–0.56)	31	49.2	0.46 (0.31–0.67)	22	135.6	0.68 (0.42–1.04)
Q4	Non-Hispanic White	14	0.7	1.00	100	8.4	1.00	306	33.5	1.00	722	99.5	1.00	493	188.5	1.00
	African-American	<5	2.9	4.12 (0.98–13.19)	14	18.1	2.15 (1.13–3.77)	30	73.8	2.20 (1.46–3.23)	62	291.3	2.93 (2.22–3.80)	24	345.6	1.83 (1.16–2.76)
	Hispanic	6	2.0	2.84 (0.89–7.85)	9	5.3	0.62 (0.28–1.24)	38	36.2	1.08 (0.75–1.52)	44	89.3	0.90 (0.65–1.22)	26	168.2	0.89 (0.58–1.32)
	Asian/Pacific Islander	<5	0.3	0.37 (0.01–2.48)	<5	1.4	0.17 (0.03–0.51)	8	5.5	0.16 (0.07–0.33)	42	57.8	0.58 (0.41–0.80)	29	156.6	0.83 (0.55–1.21)
Q5	Non-Hispanic White	19	0.8	1.00	83	5.8	1.00	341	34.1	1.00	707	98.1	1.00	514	221.4	1.00
	African–American	<5	2.8	3.44 (0.39–14.31)	10	25.6	4.44 (2.05–8.63)	19	104.2	3.06 (1.81–4.89)	19	209.0	2.13 (1.28–3.35)	13	435.9	1.97 (1.04–3.40)
	Hispanic	<5	1.0	1.21 (0.14–5.10)	<5	3.6	0.63 (0.17–1.68)	21	33.2	0.97 (0.59–1.52)	26	86.9	0.89 (0.57–1.32)	19	202.5	0.91 (0.54–1.44)
	Asian/Pacific Islander	–	–	–	<5	0.4	0.07 (0.002–0.41)	10	6.5	0.19 (0.10–0.36)	33	43.8	0.45 (0.31–0.64)	29	158.1	0.71 (0.47–1.04)

Age-adjusted to the 2000 US standard population

[15, 17, 20]. Similarly, in a multiethnic cohort study of African-Americans, Whites, and Asian-Americans, the disparity in prostate cancer survival and stage of presentation could not be eliminated by adjustment of SES and comorbidities [16]. We conducted a comparable survival analysis of men in our study diagnosed with prostate cancer from 1998 to 2002, adjusting for SES, stage, and grade; hazard ratios (HR) for prostate cancer death confirmed such disparity in risk: African-Americans (HR = 1.20; 95% CI: 1.08–1.33), Asian/Pacific Islanders (HR = 0.59; 95% CI: 0.51–0.68), and Hispanics (HR = 0.89; 95% CI: 0.81–0.98) when compared to non-Hispanic Whites.

Our findings suggest substantial influences of both innate and lifestyle factors in the differences in prostate cancer rates across groups. The consistent racial/ethnic disparity in incidence rates for all levels of SES among younger men (ages <55 years) indirectly support an important biological component to disease risk as early ages at diagnoses have been linked to biological contributors to disease. Exciting developments from recent genetic association studies, an admixture study of prostate cancer among African-Americans [28] and a multiethnic fine-mapping study [29], revealed a particular region on chromosome 8q24 that may contribute to the higher incidence of prostate cancer among African-Americans in comparison with non-Hispanic Whites. Compelling evidence provides strong support that genetic factors may account for at least part of racial/ethnic differences in disease. Lifestyle and contextual factors have yet to convincingly identify specific contributors; some studies have implicated dietary fat [30, 31], but the results are conflicting [32]. Regardless, our data suggest that the ongoing search for environmental causes of prostate cancer continues to be warranted.

Differences in treatment practices are an important consideration in evaluating racial/ethnic differences in prostate cancer mortality. Cancer registry data do not include detailed information regarding treatment, so we were unable to account for potential differences in treatment practices across racial/ethnic groups. Previous studies have reported that African-Americans are more likely to undergo less aggressive treatment than Whites [14, 33, 34], which may account for some of the observed differences in mortality. Recently, in a large California cancer registry study of differences in prostate cancer survival between African-Americans and Whites (n = 109,270), adjustment for stage and treatment eliminated most of the racial difference in survival; and with additional adjustment for SES, grade, and year of diagnosis, the survival difference between African-Americans and Whites was eliminated (HR = 1.00; 95% CI: 0.93–1.08) [13]. Although these findings indicate treatment differences are largely accountable for differences in survival, biological and environmental factors remain important contributors to racial/ethnic differences in the development of prostate cancer.

Our study has several limitations that warrant discussion. The use of a neighborhood-level index of SES is subjected to ecological fallacy such that incorrect inferences of individual levels of SES may have been made. In addition, by using overall census data to construct our index of SES, we may have overlooked factors that are particularly relevant for specific racial/ethnic groups. For example, Krieger et al. [35] report that for homes of equal value, African-Americans pay higher taxes in comparison with Whites, and for a given level of education, the economic returns are higher for Whites in comparison with African-Americans and Hispanics. This suggests that certain racial/ethnic groups at the same level of SES may not share the same level of power, prestige, and opportunities—variables that can capture these factors may improve SES measurement [22]. While we acknowledge SES may be measured with some error in our study, we have evidence that our index of SES is of sufficient quality to uncover important SES and cancer associations as seen in the literature (SES and breast cancer [22] and Hodgkin-lymphoma [36]), providing certain confidence that our SES index is valid.

There are several strengths to this study. Foremost, this is the largest and most diverse study of prostate cancer disparities to date, having 98,000 incident prostate cancer cases and 9,000 prostate cancer deaths with substantial numbers of cases from four major racial/ethnic groups. In addition, as a population-based study our findings may be generalized to the diverse population of California at large. While our use of census data to derive an area measure of SES may not completely reflect data at the individual level, area-based measures have been suggested to capture elements of the socioeconomic environment that may not be obtainable by individual-level data [37].

In summary, the present study suggests that socioeconomic status alone does not appear to account for the differences in prostate cancer burden among African-Americans, non-Hispanic Whites, Hispanics, and Asian/Pacific Islanders. Large multiethnic studies with complementary individual- and area-level measures of SES are needed to corroborate our findings. The challenge remains to disentangle the complexities of racial/ethnic differences in screening, treatment, biological and environmental factors that contribute to differences in risk across groups. Such information will greatly aid the development of more targeted interventions to improve the social inequalities in prostate cancer incidence and mortality.

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